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ABSTRACT

This study seeks to acquire understandings about the dynamics of curriculum change in one urban elementary school and to depict these understandings in a form which facilitates clarifying their behavioral implications. The focus of the study was the changing level of the use of the Developing Mathematical Processes (DMP) program. It was introduced by the principal in the primary grades at the opening of the school (1974) and to the upper grades three years later. The faculty voted, in May 1979, to discontinue DMP in favor of a textbook series which the teachers indicated also lends itself to individualized instruction. Data collection included interviews conducted with the principal and 11 of the school's 13 classroom teachers. The report contains both general implications and specific implications about curriculum implementation. (Author/MK)

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A Dynamic Model of Mathematics Curriculum Change in an Urban Elementary School

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in Connection with the Studies of
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Wisconsin Center for Research and Development
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A Dynamic Model of Mathematics Curriculum Change in an Urban Elementary School

by Alan K. Gaynor
Boston University
April, 1980

The Nature of the Problem

Historical Foundations

There is still much to be learned about the dynamics of curricular change in public schools.

Early research on educational innovations was rooted in the tradition of agricultural sociology (Havelock, 1969, pp. 10-4 ff.). It focused upon the formal adoption of new programs in schools by superintendents and school boards. It attempted to shed light on the personal characteristics of individual adopters, whom it classified into (somewhat opprobrious) categories: innovators, early adopters, early majority, late majority, laggards (Rogers, 1962).

Investigations in the sixties of educational innovations were based mainly upon earlier studies of individual influentials. Researchers of the R,D and D/Social Interaction schools studied networks of interpersonal relationships. Terms such as 'cosmopolitans' and 'locals' marked the writings of scholars preeminently concerned with the diffusion of externally developed innovations among individual adopters. Organizations, such as schools, were treated implicitly as individuals, consistent with what Graham Allison later called the 'rational actor paradigm' (Allison, 1971).

Not until the late sixties and early seventies did theorists press the distinction between the dynamics of adoption among individuals and those of implementation in organizations. Much of the research of the seventies has focused upon the processes of implementing innovative practices in schools (Gross, et al., 1971). Some investigators have particularly emphasized the importance of environmental influences upon the course of events relevant to the introduction of new programs and policies (Baldridge, 1972).

Research to date has provided useful information about several elements of the innovative process. These include knowledge of the personal characteristics of individuals engaged in adopting and promoting new practices, knowledge of the sociometry of diffusion and the role of change agents and influentials, a sense of the 'stages' of innovation and information about specific factors and techniques which can act as barriers to and facilitators of planned change(Havelock, 1969). There has also been discussion of significant ethical and philosophical issues as well as of

the particular characteristics of schools which define the climate in them for the introduction of new practices (Bennis, et al., 1976; Giacquinta, 1973; Pincus, 1974).

Need for New Research Directions

There is a need at the present time to move research on educational innovation in some important new directions.

A significant statement which has been made about American schools is that they don't tend to change very much in fundamental ways over years of observation (Goodlad and Klein, 1971). Understanding the dynamics of stability and change in schools seems, in critical ways, to require going beyond the study of novelty, per se.

This seems to imply a need to move away from the concept of innovation simply as "something new in the school" to a conceptualization which permits research to focus upon shifts in the regularities of instruction along dimensions which can be tracked over long periods of time. To do this effectively, it will be necessary to transcend the current focus upon adoption and implementation, to place increasing emphasis upon the pervasive phenomenon of discontinuation, and to study more and more the full life cycle of major dimensions of schooling. Thus, for example, it seems important to study dimensions such as individualization of instruction over periods of 20-30 years or longer. This implies seeing specific innovations in a larger context.

A major theme of change theory has been its concentration upon managerial practice. Implicit assumptions have been that change is good (those who oppose it have been commonly characterized as "resisters" and "laggards") and that the primary reason for the failure of innovations is ineffective leadership.

A fuller theory of change recognizes the existence (and legitimacy) of multiple constituencies holding diverse value positions. It recognizes that decisions in complex social systems are keyed to a variety of pressures and cross-pressures which constitute the bases of reasoned human behavior.

When the climate for change is right, effective management may be critical to success or failure, but the case literature (Baldridge and Deal, 1975) seems amply to demonstrate that long-term change is typically more than a matter of simple management; it is significantly related to deeply-held values and to the judgments of people with different values and statuses about the costs and benefits of proposed new programs. It seems important for research to develop understandings about the dynamics of cross-pressure which transcend technical managerial practice

and which define the context and limits of leadership in schools.

Finally, there is a need to move beyond the limitations of the traditional statistical paradigm. Single-equation hypothesis testing focuses analysis upon discrete, additive effects. The view of the world which this paradigm implicitly espouses (and enforces) is essentially fragmented.

Longitudinal studies of covariance have been useful in describing succinctly important observed behaviors. Such studies depict relationships among variables which constitute what can be described as whole system behaviors. Such behaviors are the result of the interaction over time of complex structural relationships. New directions in research should include systematic techniques for depicting, examining , and assessing confidence in intuited understandings about the variables and relationships which are perceived to be causing the observed trends and correlations.

This seems to suggest the need to employ methods of theory depiction and analysis which take the study of educational change beyond simply verbal descriptions or ultra-empirical number crunching. What seems fortunate is that awareness of this need coincides with the availability of an increasingly sophisticated technology to facilitate the exposition and examination of theoretical understandings and their implications for policy and further research (Forrester, 1968).

The Purpose of the Study

The purpose of the study being reported in this paper has been to acquire understandings about the dynamics of curriculum change in one elementary school and to depict these understandings in a form which facilitates clarifying their behavioral implications.

Specifically, it was hoped to acquire sufficient knowledge of the critical variables and relationships to formulate a continuous simulation model of curriculum change in that school. It was anticipated that the model would be capable of reproducing the observed historical trends associated within the time frame of the curriculum innovation we were studying and that the assumptions represented in the model would attract the confidence of the teachers and principal who had experienced the history of the innovation.

The Study Design

The Setting

The Studies of Implementation Project was proposed as a three-year longitudinal investigation of planned educational change. Specifically, the focus of the study was to explore the process by which an innovation is implemented into and becomes a pattern of individualized schooling. The investigation was designed to identify those factors or conditions that promote or retard change and relate them to the modifications they foster.

Thirteen school sites that were committed to the use of a specific innovation were selected for participation in the study. During the course of the investigation, the behaviors related to the use of the innovation were documented and analyzed. The behaviors were representative of the full range of the change process, i.e., adoption, implementation and adaptation.

A decision was made by the project staff that it would be worthwhile to apply the perspective and techniques of System Dynamics (Forrester, 1968) to the study of one of these schools. The idea was to discern and model the feedback systems which determined the course of an innovation over time.

Several criteria guided the choice of the system dynamics site. It was desirable for the school to be small and necessary for it to be convenient and for the administration and faculty to be willing to participate in the study. We were especially interested in studying a school which had undergone the full cycle of implementation and discontinuation of a particular innovative curriculum. Several possible sites were investigated. Arrangements were finally made to carry out the research in an elementary school located in a fairly large midwestern city.

The school, which we call the Mercury School, was opened as an IGE school in September, 1974, with a student population of 307. The principal was appointed six months prior to the opening of the school and was able to play a major, but not fully determining role in the selection of initial faculty.

The school population remained stable for two years. The transfer rate between September,1974, and June,1976, stood at about 2%. The city school district underwent racial desegregation in September, 1976, at which time the school population rose to a high of 540 during the 1976-77 school year. The transfer rate during that school year rose to a high of 50%. During the next two school years, the student population was stable at 457 and the transfer rate fell to 30% per year. The 1979-80 student population stands at 380; the current transfer rate is 12% per year.

The Innovation

The school's curriculum is innovative in a number of major respects. It is an IGE school with a unit organization. Instruction is strongly individualized. The Wisconsin Reading Program is the basis for reading instruction in the school as it is in the city-wide school district.

The particular innovation which became the focus for this study is called DMP (Developing Mathematical Processes). It was introduced by the principal in the primary grades at the opening of the school and to the upper grades three years later (1977-78). The faculty voted in May, 1979, to discontinue DMP in favor of a textbook series which the teachers indicate also lends itself to individualized instruction. The major characteristics of DMP are seen as its emphasis upon understanding mathematical processes (in contrast to the traditional focus upon developing specific computational skills) and induction, based upon the frequent use of manipulables by children (in contrast to the traditional use of didactic methods, verbal explanations, and word problems).

The focus of the study has been upon the changing level of use of DMP in the school during the period, 1974-80. Level of use was defined as the proportion of mathematics instruction in the school based exclusively upon the use of the materials and approaches of DMP. Level of use of DMP has been defined as diminished either by the use of supplementary materials to teach specific computational skills didactically or by the replacement of DMP with a different program of instruction. Thus, when the faculty voted to replace DMP with the textbook program, the level of use of DMP came to reflect only the use of DMP materials as supplementary (i.e., a low level of use).

It should be pointed out that when, for three years, DMP was fully implemented in the primary grades (K-2), but not implemented in the upper grades (3-6), the average level of use in the school was 33% (or less, depending upon the extent that supplementary skill materials were used by primary teachers).

Data Collection Procedures

It should be clear to the reader that the purpose of the study was to understand and describe the dynamics of curriculum change, not to assess the effects of instruction upon student learnings. To fulfill this purpose it has been necessary to collect information from knowledgeable participants toward several ends:

(1) To establish consensus about the pattern of level of use of DMP, 1974-1980;

(2) To reach shared understandings about the factors (variables) which contributed importantly to the history of DMP in the school;

(3) To reach agreement about the nature of the relationships among those variables which structured the interactions of response and counter-response which have accounted for the changing balance of implementation and discontinuation of DMP over time.

Certain assumptions underlie the approach the project has taken to data collection and analysis. Primary assumptions from the history and philosophy of science are that knowledge is always subjective (Hanson, 1958; Kuhn, 1962) and that intuition plays a necessary role in the theoretical interpretation of data (Polanyi, 1969). It has been further assumed that the major portion of knowledge which is available about organizational dynamics is neither quantified nor even written. Rather it is in the heads of people with significant experience in particular organizations.

Based upon these assumptions about the nature and location of knowledge about schools, an approach was developed by the project staff which is akin to the police artist model. In this approach to knowledge generation, people who have seen the criminal are asked to provide information about the criminal's appearance.

The key to this approach to data collection lies in its reliance upon the dynamics of feedback and consensus. Information is sought from multiple observers and, critically, a process is established whereby there is an ongoing information exchange between the artist and the witnesses. The central role in this process of information exchange is played by the sketch, itself. As the drawing unfolds, witnesses respond to it and changes are made incrementally by the artist in the course of what becomes a series of successive approximations toward consensus. In an analogous manner, the police artist paradigm guided the data collection process employed in the Mercury School.

Initial Data Collection

Initial data were collected in a series of recorded hour-long retrospective interviews with the principal of the Mercury School and eleven of its thirteen classroom teachers. Individual teachers were interviewed once each, some singly, others in pairs. The principal was interviewed alone on several occasions.

Interviews were held almost always by all three members

of the project staff (never by less than two of the three). Infrequent differences in factual recollection have been reconciled by reference to the tapes and transcriptions and, if necessary, by rechecking with the teachers or principal. The only fact which was never able to be clarified with certainty had to do with the exact count of the vote to discontinue DMP. There is unanimous agreement about the result of the vote but irresolvable lack of clarity about whether it was close or one-sided. (It can be argued that this situation is, perhaps unfortunately, representative of the essential problem of data collection in the social sciences. All data are perceptual (Hanson, 1958) but doubly so in the social sciences. The subjectivity of social data is embedded both in the observer (as in all sciences) and in the observed.)

Initial interviews have also been held by the entire project staff with the principal and two unit leaders of what we have called the Jupiter School. It, too, is an IGE school where DMP has been used for a comparable period of time for mathematics instruction. The difference is that in the Jupiter School DMP has been implemented only in the primary grades. It is interesting that in the Jupiter School there continues to be strong support for DMP among the teachers who use it.

Follow-up Data Collection

Central to the police artist methodology is the concept of feedback and refinement. Preliminary sketches are drawn which become the basis for feedback and successive approximation. Following the initial interviews in the Mercury School, a meeting was held at which the principal and almost all of the faculty were present.(1) At this first feedback session, the project staff shared with the teachers its major understandings about the course of DMP over the period to that point in time. Consensus was reached with the principal and faculty about the shape of a graph depicting the average level of use of DMP in the school between the 1974-75 and 1979-80 school years. This graph came to be called the "reference behavior graph" because it constituted the reference behavior which the study was seeking to explain. The reference behavior graph is

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(1) Substitutes had been provided at project expense who freed teachers for the initial interviews during regular school hours. Teachers were paid by the project for participation at sessions held prior to and after regular school hours.

displayed in Figure 1.

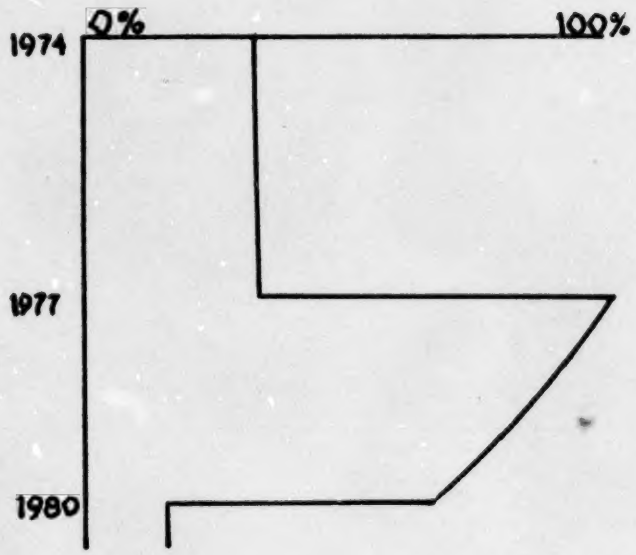

Fig. 1. The Reference Behavior: The Level of Use of DMP in the Mercury School (1974-1980).

During the next 2-3 months, work proceeded on the clarification of the assumptions which comprised the project's understandings of the factors and relationships which explain the reference behavior. As a central part of this process of clarifying theoretical assumptions, a continuous simulation model of mathematics curriculum change at the Mercury School was constructed at the Boston University computing center.

The formulation of this computer model has been the project's most sophisticated analog to the police artist's sketch. The model became the vehicle by which it has been possible to test the behavioral implications of emerging theoretical assumptions. The twin objectives of the test procedures have been to clarify the extent to which the assumptions upon which the model was founded are credible to those who best know the history of DMP in the Mercury School and to assess the model's ability to reproduce the reference behavior shown in Figure 1.

The last portion of the data collection procedure was designed to report to the principal and teachers progress with our emerging understandings and once again to solicit feedback from them on the assumptions which comprised the theoretical model. A session was held at the school from 4:00-5:30 p.m. The principal and most of the teachers were present. Feedback from teachers and principal on the first

formulation of the model was sought and given specifically with respect to the accuracy of specific parameters (e.g., initial values of variables, annual changes in transfer rates, and district-wide test results). Feedback data obtained during this session became the basis for refining both the reference behavior graph and the model, itself.

For example, the feedback session reinforced understandings from earlier data that the structural differences between intermediate and primary grade teachers were central to understanding the history of DMP in the Mercury School. In addition, it became clear that "primary grades" in this context meant grades K-2. In a sense, grades 3-4 had become the battleground between those who believed that DMP was good for young children and those who espoused the need for greater emphasis in the mathematics curriculum upon the direct teaching of specific computational skills.

Teachers in grades K-2 were, it seems, relatively protected from the pressures exerted by the upper-grade teachers to prepare students for the district-wide achievement tests (which are administered in that district to fifth grade students).

This clearer understanding about the distribution of values and pressures led to a tentative reformulation of the model(2). As a result of this finding, the model was reconstructed to display the relative isolation of the K-2 teachers in contrast to the substantial pressures felt by teachers in grades 3-6. These pressures, it was reported, were generated by problems caused by differences between mathematics teaching at the Mercury School (DMP) and that of teachers and administrators in the rest of the school district (non-DMP). These problems were most intensely felt in dealing with transfer students (3) and in confronting the

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(2) Work is currently underway to reformulate the model in a major way to accomodate this "tripartite" division of the Mercury School into Primary (K-2), Intermediate (3-4), and Upper (5-6) grades. Reformulation of the model will allow not only a more accurate representation of the historical reality of the school but it will also facilitate a clearer conceptualization of the "battleground" concept which emerged in our last session with the principal and teachers. We want to explore further the generation of conflict in the school over DMP and to represent the role of conflict structurally in the model. Given the time constraints associated with the writing of the current paper, the reporting of the results of this reformulation will have to await the publication of the technical report of the project. Minor inaccuracies in the current formulation of the model will be corrected in the revised version. These have to do with the precise timing of the introduction of DMP into the third and fourth grades.

(3) For example, the transfer rates in 1976-77 and 1977-78

markedly low standardized achievement test scores associated with DMP (4).

Results

The Dynamic Hypothesis

A set of understandings about the factors and relationships among factors which affect decisions about curriculum in the Mercury school have emerged from the interview data and from the subsequent feedback processes which characterized data collection over the course of the study. These understandings can be expressed in the form of a broad hypothesis about the dynamics of curriculum change in the school. This hypothesis is formulated below with specific reference to DMP:

> The level of use of DMP in the Mercury School is a function of crosspressures generated over time by discrepancies between the salient characteristics of the innovation and the value priorities of interacting system elements.

Major system elements include primary and upper grade teachers and students; the principal of the school; parents; and other units of the city-wide school district. The effects on the curriculum of some discrepancies are stronger then those of others and the curriculum responds by seeking equilibrium at a level which balances out the crosspressures.

The effects upon the curriculum of school district norms and practices are mediated by standardized test scores and by the need of teachers to deal with students coming in from other schools. For example, the higher the transfer rate, the greater the impact of discrepancies between the Mercury School's curriculum and that of other schools in the district.

It is also assumed that there are significant developmental differences between primary and intermediate grade students, differences which can be affected somewhat by instruction but which to some extent are developmental.

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were reported as 50% in each year.
(4) A sophisticated analysis was done of the 1978 achievement test results. It was reported by teachers that differences in reading and math test scores were as great as 50% (6th grade in reading vs. 3rd grade in math). It was further reported that the longer students had received instruction in DMP, the lower their scores on the district-wide standardized achievement test.

Broadly speaking, the theory put forth in the dynamic hypothesis characterizes the curriculum decisionmaking system in the form of a thermostat model. In this kind of model, the critical value (e.g. of heat in one's home) is seen as responding to pressures generated by a discrepancy with a desired value (i.e., the thermostat setting). In the Mercury School model, there are multiple settings which are seen to be influencing decisions about curriculum. One of these settings, a powerful one, is external to the school, itself. This "thermostat" setting is found in the norms and practices of the school district as a whole. School district norms are manifested in materials and methods of teaching in the majority of its schools, in the values and expectations of the central administration and, significantly, in the values which characterize the standardized tests to which teachers, administrators and students are held accountable. School district norms and practices are viewed as unaffected by the norms and practices of any one school in the district.

Whereas school district norms and practices are assumed to be exogenous, the other factors comprising the model are perceived as responding reciprocally to pressures from one another. Thus, primary and intermediate teachers influence one another. Both influence and are influenced by the principal and parents. Teachers and students influence each other and all influence and are influenced by the current state of the curriculum.

Policy decisions constitute responses at particular moments in time which are generated by the cross-pressures produced by these multiple "thermostat settings." Although the effects of such decisions may be diluted by subsequent counterpressures, their influence at particular points in time can be powerful. The vote on a particular policy decision may be close, for example, but its effects can be dramatic, at least in the short run, because these policy decisions control not only expectations but resources as well. Also, they carry the weight of binding authority. Thus, they operate much like switches, dichotomous rather than continuous in their effects. In this way, small differences may be magnified in the form of policy decisions which take the school one way or another at a particular point in time.

Model Behavior

A continuous simulation model (5) has been formulated

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(5) The specific modelling approach employed is called System Dynamics. It was developed by Forrester (1961) and employs a compiler program called Dynamo II. Other versions of the compiler, including Dynamo III and Mini-Dynamo are currently available. Information may be obtained from

based upon a set of understandings about curriculum change at the Mercury School, understandings which derive from the interview data and which have been refined by the interactive process of data collection described earlier with reference to the "police artist model." Major assumptions which have been built into the computer model include the following:

1. Both school policy and teacher judgments affect changes in school curriculum.

2. Teachers are able to affect curriculum policy directly and indirectly--directly by the manner in which they use the curriculum and indirectly by their influence on the principal.

3. Teacher judgments about curriculum policy are influenced by many factors:

   a. The principal as persuader;

   b. The principal as resource provider;

   c. The judgments of fellow teachers and, to a lesser extent, parents;

   d. Teacher perceptions about what is best for the age level of the students they teach;

   e. Extra workload (real and perceived);

   f. Differences between the school and citywide curriculum, especially as reflected in test scores and difficulty in placing transfer students and in adapting them to the school's curriculum.

4. Test scores and transfer students have a differential effect on the perceptions of teachers in the primary and upper grades. (6)

Push-Roberts Associates, 5 Lee Street, Cambridge, Massachusetts.

(6) The full set of equations which comprise the Mercury School model is included in an appendix to this paper. The reader may wish to compare the verbal descriptions of the assumptions upon which the model is founded with the model equations through which those assumptions are incorporated in the model program.

Model Outputs

The Base Run. The purpose of the base run is to evaluate the extent to which the model is able to reproduce the reference behavior. Basic confidence in the model is related to the credibility of the assumptions upon which it is founded and, importantly, upon the model's ability to reproduce accurately the reference behavior which it is seeking to explain. The reference behavior represents empirical behavior in the real world. The reader will want to compare the average level of use of DMP from 1974-80 which the model produces (Figure 2, below) with the reference behavior the teachers and the principal agreed was an accurate representation of the history of the actual average level of use during that period of time (Figure 1, supra, p. 9). Note that the model output is consistent with the Staff's perceptions not only with respect to the average level of use but especially in the distinction between the primary and intermediate grade levels of use.

TIME e+00	PTDDMP e+00	ITDDMP e+00	ADDPMS(7) e+00
.0	90.000	50.000	63.333
4.	89.056	49.383	62.607
8.	88.105	49.959	62.675
12.	87.182	51.866	63.638
16.	86.313	54.377	65.022
20.	85.472	56.819	66.370
24.	84.583	58.872	67.442
28.	83.641	60.470	68.194
32.	82.708	61.708	68.708
36.	81.821	62.655	69.044
40.	80.985	62.288	68.520
44.	80.182	57.981	65.381
48.	79.441	47.324	58.030
52.	78.813	34.876	49.522
56.	78.306	27.714	44.578
60.	77.924	23.328	41.527
64.	77.631	21.016	39.888
68.	77.557	22.585	40.909
72.	77.655	29.674	45.668

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(7) Each of the remaining figures displays a table and a graph. The reader should note that the variables printed in the table are not the same as those which are plotted in the graph. What are plotted are the levels of DMP in the Mercury School over time. What the reader sees are the percent of DMP in the primary and intermediate grades throughout the model run. Also displayed is the average percent of DMP under the same conditions during the same time period. The computer symbols are as follows: A=average DMP; P=primary grade DMP; I=intermediate grade DMP. The reader will recall that the primary grades are K-2 and that the intermediate grades are 3-6. Thus in calculating the average DMP, the intermediate grade value is weighted twice. The computer symbols have also been drawn over with clearer markings. Average DMP is marked with a solid line, primary DMP with a dashed line, and intermediate DMP with a chain (o-o-o-o-o).

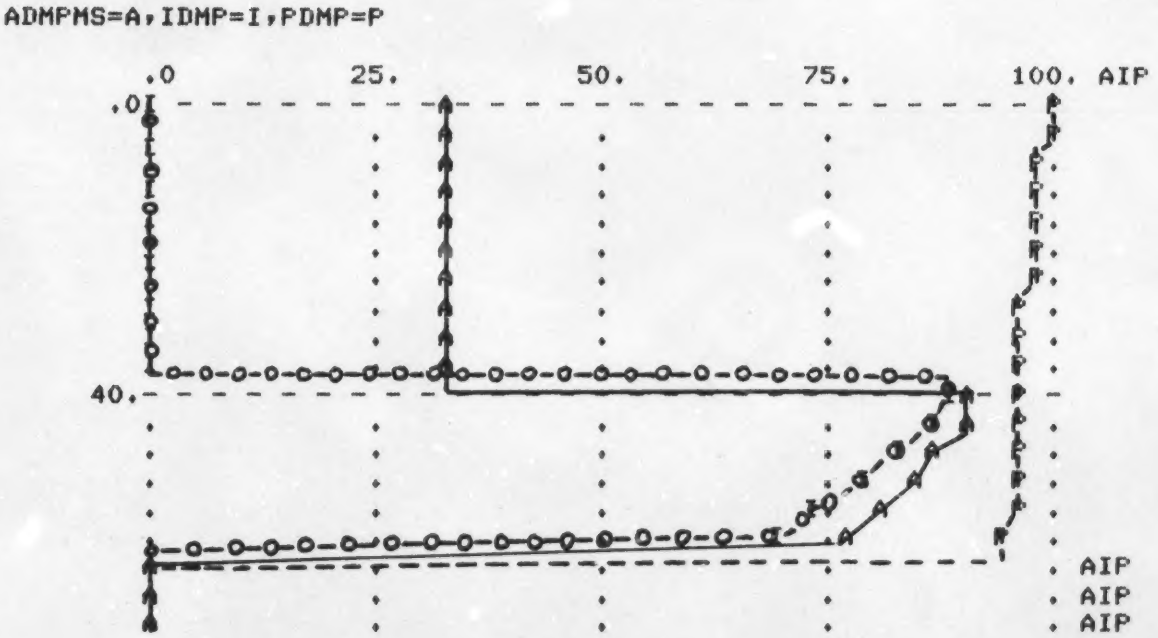

Fig 2. Base Run. Average (ADMPMS), Primary (PDMP), and Intermediate (IDMP) Grade Levels Use of DMP in the Mercury School, 1974-80. (Scales indicate 0-100% level of use.)

It should be noted that the base run is not a normal run typical of continuous simulation models. As indicated earlier, one of the interesting issues that this research raised was the impact, at least in the short run, of dichotomous policy decisions. A reasonable argument can be made that when consideration is given to a longer time frame (e.g. 25-50 years), the apparently dramatic effects of these "policy switches" is smoothed out over the long curve. Thus, it was interesting to compare a "normal" run (i.e., one without policy switches) with the base run, which incorporates the impact of several policy decisions, including the vote of the faculty, in 1979, to formally discontinue DMP in the school after five years (60 months in the model) of use. It should also be pointed out, though, that the policy switch in the model was "thrown" internally, based upon a decision that if the average desired DMP was less than 50% it was reasonable to assume that DMP would be voted down. It is, in fact, "voted down" in the model just as it was in real life in the Mercury School.

In what we are calling the normal run, several aspects of structure become different from the base run. First of all, the upper grades (what are called "intermediate grades" in the model) are not prevented from using DMP if they wish, even before the the three year waiting period (which was a policy decision by the principal in the real situation.) Secondly, neither they nor the primary teachers are pushed by policy to implement DMP at any time. The assumption is, however, that, as in the real situation, the principal is highly supportive of DMP. Furthermore, the intermediate grade teachers are able to experience DMP from the beginning and, therefore, to be affected by this experience.

In this run, both primary and intermediate teachers are assumed to start from non-use of DMP. By way of contrast, in the base run, the primary grade teachers are presumed to start at full use of DMP, as the result of an initial policy decision by the principal. The "normal" run is shown in Figure 3, below. It can be seen that in the "continuous mode" as well as in the "policy mode" DMP is clearly favored more by primary grade teachers than by intermediate grade teachers but that even among the primary grade teachers, discontinuation occurs after experience with the innovation over time. This is still assuming a principal who is strongly in favor of the process-oriented curriculum.

TIME e+00	PTDDMP e+00	ITDDMP e+00	ADDPMS e+00
.0	90.000	50.000	63.333
4.	89.097	48.274	61.881
8.	88.355	45.628	59.870
12.	87.628	41.450	56.843
16.	86.822	36.801	53.475
20.	85.945	31.752	49.816
24.	84.951	25.397	45.248
28.	83.843	18.707	40.419
32.	82.688	14.083	36.951
36.	81.523	11.213	34.650
40.	80.360	9.332	33.008
44.	79.229	7.957	31.714
48.	78.203	6.922	30.683
52.	77.262	6.156	29.858
56.	76.425	5.752	29.310
60.	75.722	5.791	29.101
64.	75.126	6.299	29.242
68.	74.594	7.233	29.687
72.	74.091	8.460	30.337

ADMPMS=A,IDMP=I,PDMP=P

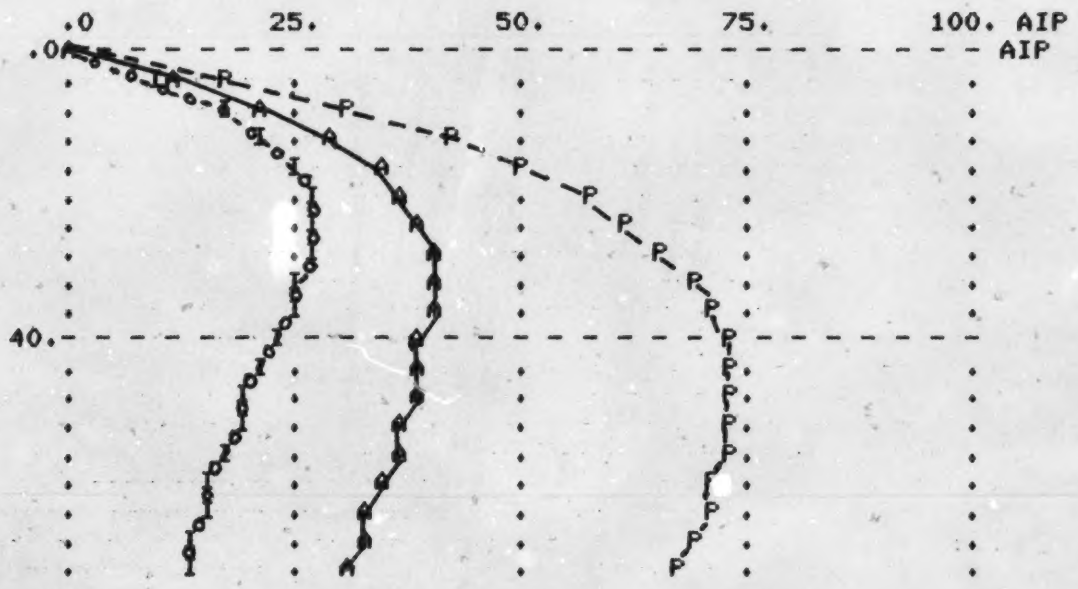

Fig. 3. The 'Normal' Run--Without the Effects of Dichotomous Policy Decisions.

Tests of Effects

One of the utilities of expressing theory in the form of a continuous simulation model is that the model can be used to test the sensitivity of the situation to the individual and joint effects of specific variables. In important ways, such whole model tests of effects may be superior to similar efforts using statistical approaches. In a persuasive study done at M.I.T., Mass and Sense concluded that single equation tests of significance may be particularly susceptible to type II error with even low levels of data error (Mass and Sense, 1976

A large number of tests of effects have been performed with the model, more than it would be profitable to reproduce here. However, several examples are shown, both to illustrate the procedure and to suggest some possible implications.

The Effects of the Principal. In the real Mercury School, the principal was a strong advocate of DMP. She chose it as the math curriculum in the primary grades at the time the school was first opened and the intermediate grade teachers have reported that she was influential in persuading them to accept it in 1977. In important ways, a principal, although clearly not all-powerful, commands important sources of influence and leverage in a school. Together with her own leadership skills, this principal had positional authority, which was respected by the teachers, and control over important resources. These include, not insignificantly, control over fiscal resources for curriculum materials. The interviews, both in the Mercury and Jupiter schools, make clear the impact that the withdrawal of even a few hundred dollars per year can have on the ability of teachers to continue to implement an innovation, even one in which they have a vital interest.

Thus it seems useful to examine the effect of the principal on the course of the innovation, given the assumptions built into the model. It was our intent to compare this run (Figure 4), in which the effects of the principal are neutralized, with the base run (Figure 2).

TIME e+00	PTDDMP e+00	ITDDMP e+00	ADDPMS e+00
.0	90.000	50.000	63.333
4.	89.098	48.339	61.925
8.	88.381	46.612	60.535
12.	87.752	44.294	58.780
16.	87.103	41.325	56.584
20.	86.345	37.458	53.754
24.	85.423	31.793	49.670
28.	84.365	24.775	44.638
32.	83.250	18.990	40.410
36.	82.121	15.365	37.617
40.	80.993	13.052	35.699
44.	79.869	11.451	34.257
48.	78.816	10.295	33.135
52.	77.860	9.450	32.254
56.	77.014	9.019	31.684
60.	76.299	9.131	31.520
64.	75.687	9.777	31.747
68.	75.136	10.786	32.236
72.	74.617	11.865	32.782

ADMPMS=A,IDMP=I,PDMP=P

Fig. 4. Model Behavior without the Effects of the School Prin

Clearly, withdrawing the effects of the multifold influence of the principal on the school changes the pattern of innovation significantly. Not surprisingly, when the effects on the curriculum of the principal are withdrawn, the results bear a striking resemblance to the "normal" run (see Figure 3, supra, p. 18). This, of course, is because principal is the carrier of policy in the school, as well as influencing teachers directly. Therefore, when the effects of the principal are removed, there are no binding policies with respect to curriculum. Rather, teachers are free to respond on their own to the pressures which operate in the environment. The reader will remember that the absence of binding policy was the defined condition in the "normal" run.

Given the assumptions undergirding the model, there are at least three other variables which one might expect to be powerful enough to alter significantly the pattern of the innovation over time. These are student fit, the transfer rate and the results of the test scores on the standardized mathematics test.

There is solid empirical evidence, reported consistently in the course of the interviews, supporting the important effect the test scores had in paving the way for the formal discontinuation of DMP in the Mercury School (see related material in footnote, supra, p. 11). On the basis of that analysis, several things are clear. First, the test scores of the Mercury students were low, not only in comparison to the math scores of other schools but also in comparison to the students' own reading scores. Second, the longer students were exposed to DMP, the worse were their scores on the districtwide test. Third, the results of the test scores were influential with many teachers. This was especially true of the upper-grade teachers. It is apparently also true of the 3-4 grade teachers, who have told us that they felt great pressure around the test.

Another critical variable, at least one that was mentioned in almost every interview, is the transfer rate. This is an exogenous variable, not influenced by events or policies in the school. It has the effect in the model of multiplying the effects of discrepancies between the school's and the school district's curricular norms and practices. When the schools' curriculum, as was the case in mathematics with DMP, is significantly different in important ways from the vast majority of other schools in the city, students transferring in from other schools don't fit very well with the curriculum. Teachers in the Mercury School reported with great frequency problems in placing transfer students accurately in groups. The reason teachers gave was that transfer students tended to be comparatively advanced in their computation skills but comparatively behind in their understanding of mathematical processes. Teachers in the Mercury School also reported that they often had to spend a great deal of time reteaching transfer students, especially with respect to the differences in orientation and terminology. Primarily because of citywide

racial desegregation, the transfer rate to the Mercury School rose dramatically for three years, 1976-79.

Finally, it seemed clear from the interview data that a critical variable for teachers in making curriculum decisions is the perceived fit of the curriculum with the developmental learning mode of their students (Wadsworth, 1979). One of the key points of difference between primary teachers and those who were teaching older students was in their perceptions of how they learned best. Teachers of young children seem much more comfortable with the use of manipulables. Teachers of older children seem to put much more emphasis on didactic methods and verbal approaches.

A very important caveat should be put forth before we embark on an analysis of the test results. As indicated earlier, the base run, which is the logical point of reference for assessing the test results, is not a normal run for a continuous simulation model. Continuous simulation models have proven to be most useful in analyzing the effects of policy interventions upon the problem system's patterns of response. The primary concern of continuous simulation is to understand the dynamics of these response patterns. It is not to make what are commonly called "point predictions."

For example, in this study of mathematics curriculum change in the Mercury School, what we are trying to understand are the nature of the counterpressures to which the curriculum responds. That the curriculum is powerfully influenced by school district norms and practices is important. That the pressures from these norms and practices are strongly mediated by standardized tests and by the impact on teachers of students coming in from other schools in the district is important. It would be helpful to be able to predict precise values at particular points in time. Clearly, this would demonstrate what most would likely consider "perfect theory." However, what is critically important for the assessment of policy alternatives is to understand the interaction of proposed policies with other variables in the problem system and to be able to predict the kinds of effects (i.e., the trends) which are likely to derive from different policy choices.

The caveat to be placed before the reader has to do with the sensitivity of the exact timing of policy decisions to certain parameters in the model. The trends which the model describes, trends which appear to be highly consistent with the history of DMP in the Mercury school, are quite stable. They are generally insensitive to parameter changes. However, to fit the timing of the actual policy points that were followed in the Mercury School situation, it is necessary that the specific value of the averaged desired DMP (ADDPMS) be less than 50% at month 60 (i.e. at the end of year five). Now, the reader needs to be clear that there is no way to "fix" this result unless the basic trends are consistent with its occurrence. The point is that depending upon the value of the normal fractional rates of increase

and decrease, the point at which the value of average desired DMP falls below the "magic policy decision point" may vary by a year or so one way or the other. Thus, in interpreting the test results, it seems important for the reader to know precisely how the fractional rate parameters were set.

As has been pointed out, the one fact that has not been possible to establish with certainty is the exact vote which led to the formal discontinuation of DMP in the Mercury School. The best understanding we have been able to attain is that a 60-40 split among the faculty against DMP is in the ball park. With this in mind, the fractional rates were set at a value (=.005) which allowed the average desired DMP to fall at approximately 40% (precisely 41.527) at the time the vote was taken. Again, as indicated above, this was possible only because the basic trend was one of a falling ADDPMS. The trend derives from the internal structure of the model, not from "playing with parameters."

Actually this approach has turned out to be interesting. What it has done is to set up a point of comparison which, in some ways, may be more readily meaningful to many readers. Having placed the base run at the known value at the time of the vote, it now becomes possible to compare the value of the average desired DMP at the same point under different test conditions. The results seem illuminating. (NOTE: Once established, the normal fractional rates are constant throughout the analysis. They do not change from one run to another.)

By way of providing an overview prior to observing the test results, what seems to emerge clearly is a two-fold phenomenon. First, we see a stable pattern of outcomes which appears to be substantially robust with respect to the effects of single, or even multiple variables. Second, individual or combinations of variables appear to impact upon the system primarily by changing the slopes of its response patterns. The result is that the main trends remain highly resistant to change. At the same time the trends are shifted, sometimes substantially, so that the value of the average desired DMP at the time of the 1979 vote can be quite different under different test conditions. The implication seems to be that DMP might have lasted a lot longer in the Mercury School under certain conditions than under others. For example, an experiment was done to test this idea. The model was run under a combination of highly favorable assumptions for a long period of time (30 years).(8) Even over this long period of time, two patterns stood out. These were the same patterns which were evident in the shorter (6 year) run. The first was that there was a

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(8) The assumptions were (1) no standardized tests, (2) no transfer students and (3) a very high (100%) fit between DMP and the developmental learning characteristics of students.

very slow, but continuing decline in average desired DMP. The other was that, at the end of the run, support for DMP was still high (72.7%).

In the following figures, the reader is presented with graphical output from the computer model which provides information about the results of the tests described above. In examining all of the test runs, the reader will want to compare the results with the base run. To the extent that a particular test run is different from the base run, it can be inferred that the test variable has a singular effect upon the behavior of the model. The first of these figures (Figure 5) shows the behavior of the model without the effects of the test scores upon the teachers.

TIME e+00	PTDDMP e+00	ITDDMP e+00	ADDPMS e+00
.0	90.000	50.000	63.333
4.	89.079	49.299	62.559
8.	88.263	49.219	62.234
12.	87.534	49.850	62.411
16.	86.857	50.925	62.902
20.	86.188	52.174	63.512
24.	85.450	53.410	64.090
28.	84.635	54.535	64.568
32.	83.801	55.516	64.944
36.	82.982	56.351	65.228
40.	82.191	56.591	65.124
44.	81.431	56.429	64.763
48.	80.706	54.549	63.268
52.	80.020	50.557	60.378
56.	79.438	46.723	57.628
60.	79.015	44.604	56.024
64.	78.711	43.825	55.454
68.	78.468	43.755	55.326
72.	78.247	43.912	55.357

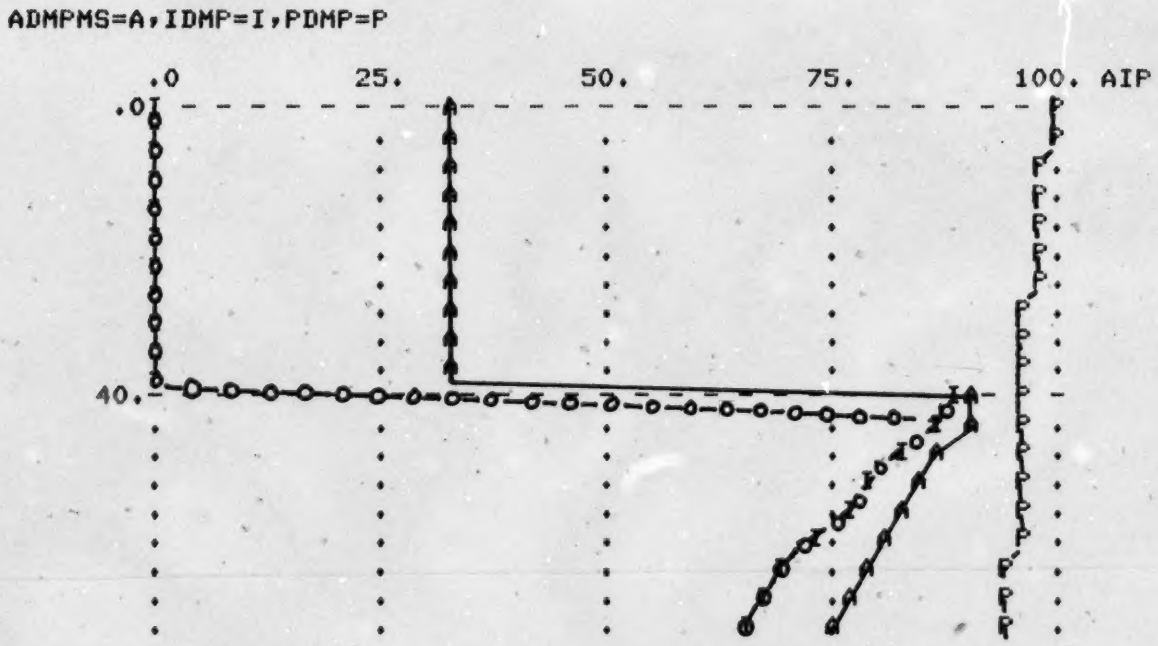

Fig. 5. Test Run Removing the Impact of Test Scores on Teache

In the second figure, we observe the effects of the transfer rates on the system (figure 6).

TIME e+00	PTDDMP e+00	ITDDMP e+00	ADDPMS e+00
.0	90.000	50.000	63.333
4.	89.056	49.383	62.607
8.	88.109	49.959	62.676
12.	87.190	51.866	63.640
16.	86.327	54.377	65.027
20.	85.510	56.819	66.383
24.	84.730	58.872	67.491
28.	83.979	60.470	68.306
32.	83.256	61.707	68.890
36.	82.562	62.654	69.290
40.	81.893	62.081	68.685
44.	81.229	57.771	65.590
48.	80.580	50.613	60.602
52.	79.958	44.400	56.253
56.	79.395	40.284	53.321
60.	78.901	37.803	51.502
64.	78.457	36.062	50.194
68.	78.054	34.729	49.171
72.	77.833	36.413	50.220

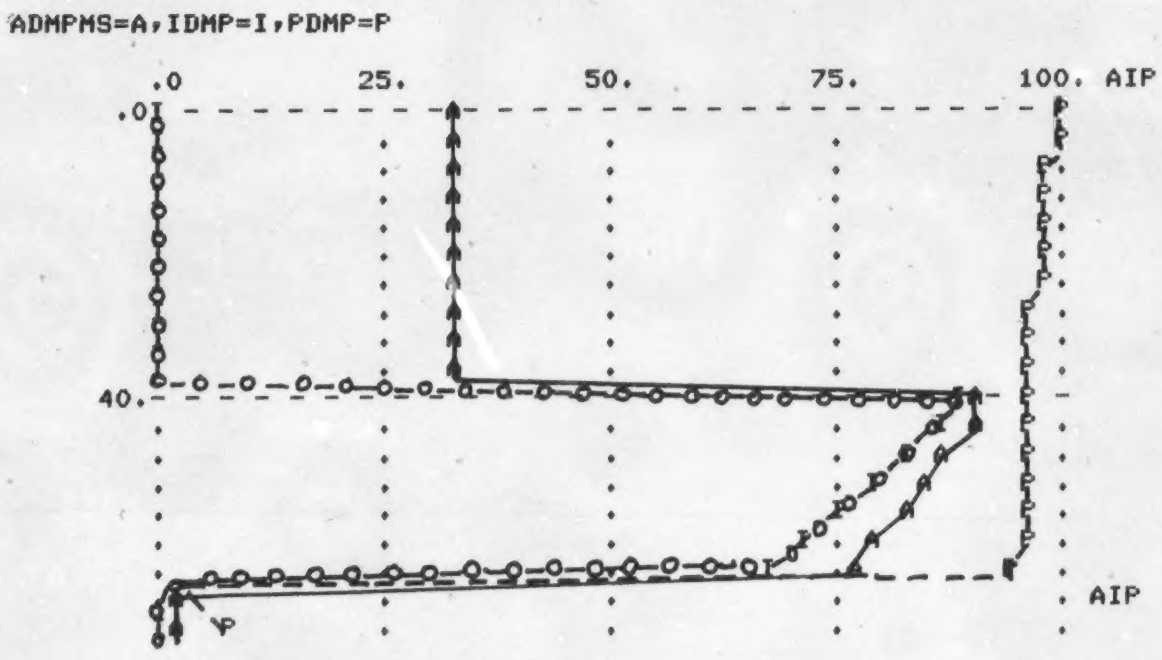

Fig. 6. Test Run Removing the Impact of the Transfer Rate on

The third figure shows the combined effects of test scores and the transfer rate on the behavior of the model (figure 7).

TIME e+00	PTDDMP e+00	ITDDMP e+00	ADDPMS e+00
.0	90.000	50.000	63.333
4.	89.079	49.299	62.559
8.	88.267	49.219	62.235
12.	87.542	49.850	62.414
16.	86.870	50.925	62.907
20.	86.224	52.174	63.524
24.	85.587	53.410	64.136
28.	84.953	54.535	64.674
32.	84.319	55.516	65.117
36.	83.685	56.351	65.463
40.	83.056	56.473	65.334
44.	82.434	56.262	64.986
48.	81.829	55.387	64.201
52.	81.245	54.368	63.327
56.	80.687	53.549	62.595
60.	80.160	53.006	62.052
64.	79.678	52.733	61.715
68.	79.267	52.621	61.503
72.	78.918	52.598	61.371

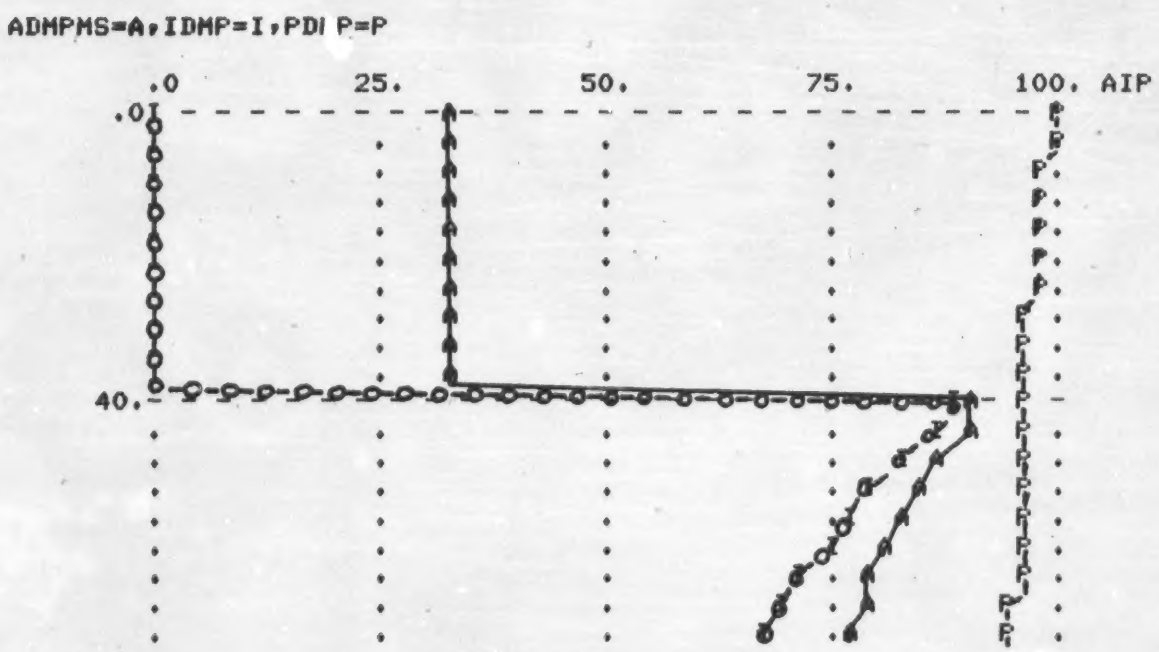

Fig. 7. Test Run Removing the Combined Effects of Test Scores and the Transfer Rate on Teachers.

The pattern thus far has been to examine the effects of these variables sequentially, to take them in order and to examine their effects singly and then in combination. In the next figure, we move on to the next critical variable, student fit with DMP, but we look at the effects of the variable in combination with testing and transfer before examining its singular effects.

The reason for this shift in the established sequence is to facilitate the raising of an interesting point. The effects of student fit in combination contrast illuminatingly with its singular effects. The result of this contrast is to illustrate a common finding in studying complex systems. This finding has become almost an adage among some systems analysts: "What is better in the short run may be worse in the longer run."

In Figure 8 three assumptions are combined which produce important positive results with respect to support for DMP. In this test run, the behavior of the system is observed assuming that (1) there are no standardized test results to contend with, (2) there are no transfer students to be dealt with and (3) student fit with DMP, both primary and intermediate, is assumed to be perfect.

TIME e+00	PTDDMP e+00	ITDDMP e+00	ADDPMS e+00
.0	90.000	50.000	63.333
4.	89.079	54.726	66.177
8.	88.267	60.313	69.631
12.	87.546	67.128	73.934
16.	86.885	73.713	78.104
20.	86.273	78.052	80.793
24.	85.726	80.708	82.380
28.	85.255	82.447	83.383
32.	84.857	83.567	83.997
36.	84.522	84.230	84.327
40.	84.237	84.381	84.333
44.	83.993	83.632	83.752
48.	83.781	81.678	82.379
52.	83.591	79.137	80.622
56.	83.412	76.998	79.136
60.	83.234	75.430	78.031
64.	83.051	74.326	77.235
68.	82.862	73.563	76.663
72.	82.667	73.051	76.256

ADMPMS=A,IDMP=I,PDMP=P

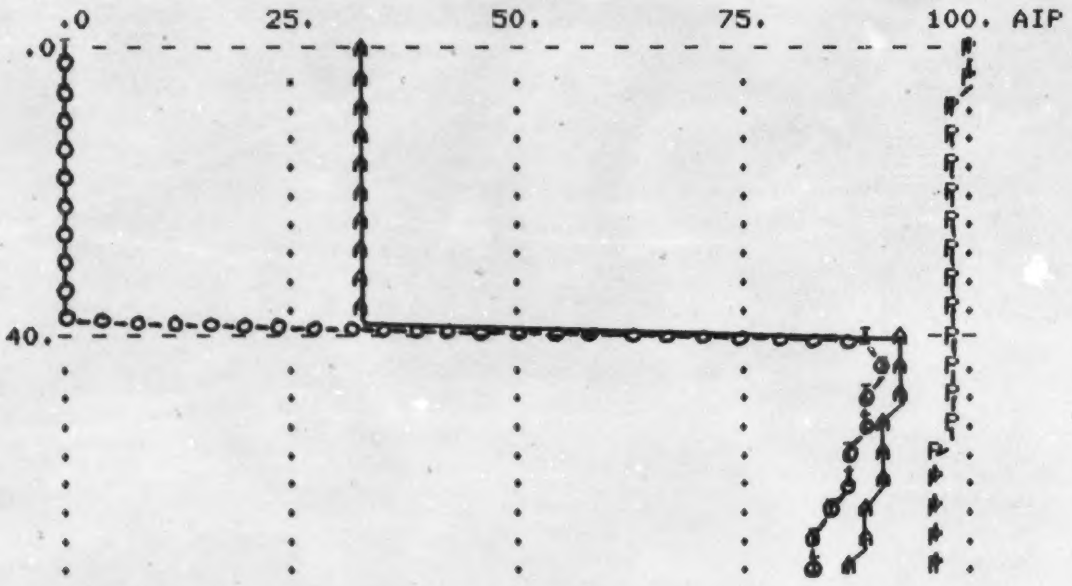

Fig. 8. Test Run Showing the Combined Impact of Test Scores, Transfer Rate and High Student Fit with DMP.

It is clear that the combined effects of the three variables on the behavior of the model are substantially greater than the singular effects of either the transfer rate or the test scores. They are also substantially greater than the combined effects of just the transfer rate and the test scores. The following table illustrates the differences in effect upon the average desired DMP in the Mercury School (ADDPMS). In each case the value of ADDPMS shown is the value at month 60 (i.e., at the time of the vote).

TEST VARIABLE	VALUE OF ADDPMS AT THE TIME O
Base Run	41.527
Transfer Rate Only	51.502
Test Scores Only	56.074
Transfer Rate and Test Scores	62.057
Transfer Rate, Test Scores and Student Fit	78.031

It may be tempting to conclude that the effects of student fit are the most important effects. Data provided in Figure 9, however, serve to temper this conclusion.

TIME e+00	PTDDMP e+00	ITDDMP e+00	ADDPMS e+00
.0	90.000	50.000	63.333
4.	89.056	55.295	66.549
8.	88.106	64.637	72.460
12.	87.186	75.742	79.557
16.	86.340	81.897	83.378
20.	85.580	85.501	85.528
24.	84.861	87.553	86.656
28.	84.178	88.575	87.109
32.	83.583	88.920	87.141
36.	83.089	88.814	86.906
40.	82.680	87.789	86.086
44.	82.318	81.298	81.638
48.	81.989	67.815	72.540
52.	81.670	46.390	58.150
56.	81.346	28.322	45.997
60.	81.022	20.735	40.831
64.	80.687	17.797	38.760
68.	80.488	19.003	39.498
72.	80.416	25.566	43.849

ADMPMS=A,IDMP=I,PDMP=P

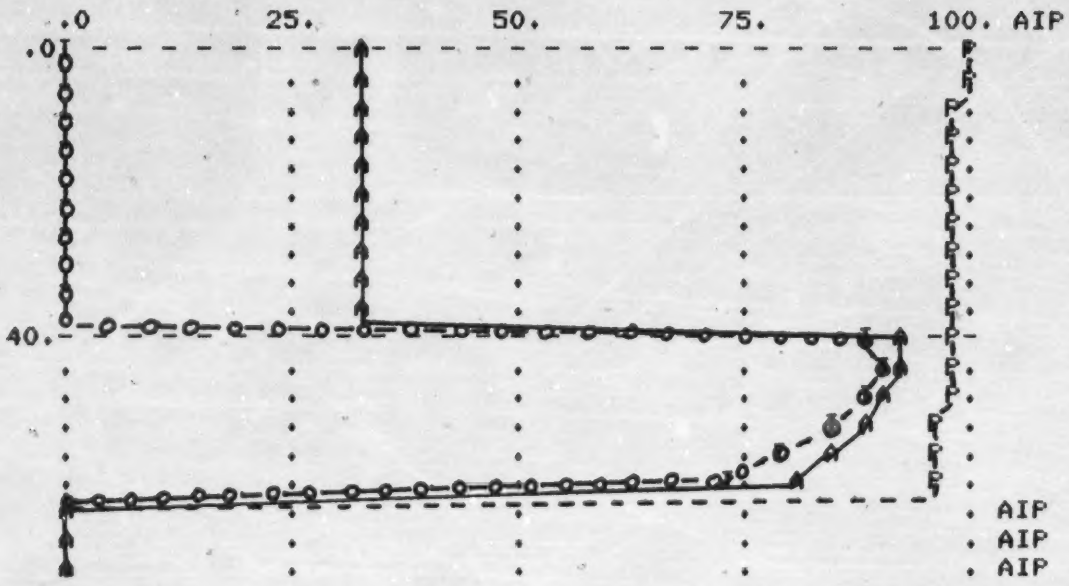

Fig. 9. Test Run Showing the Effects of High Student Fit with

The reader will notice that, in this run (Figure 9), the impact of student fit is quite different than we found it to be earlier. In combination with no standardized tests and no transfer students, high student fit added considerably to the short- and long-term value of average desired DMP. By itself, this is not at all the case. The value of ADDPMS in this run is no higher than in the base run (in fact it is a shade lower). How can we account for what may appear to be an unexpected result? The explanation seems to lie in two general systems concepts. One was mentioned earlier: "Better can sometimes lead to worse." The other concept lies at the center of systems thinking. It is that the essence of systems behavior lies in the interactions among variables. What happens in this case is common. The effects of transfers and testing are delayed, partly because that is the reality (i.e., the physics of the situation) and partly, in this particular case, because the intermediate teachers didn't actually experience DMP in their own classrooms for three years. (The reader will remember that this was a matter of the principal's policy--easily implementable since there was no overwhelming enthusiasm for DMP among intermediate teachers, anyway.) Thus, the effect of the high student fit, real and perceived, is to raise the level of DMP (and the desired level of DMP) to substantially higher values two and three years into the run. The longer-term result is that when "reality rears its ugly head" (in the form of poor test scores and difficulties with transfer students, especially in the upper grades), the fall is greater than under conditions where the early "high" was not attainable. In more technical language, the reader will observe that the rate of decline is sharper in this run than in the base run. (Notice, particularly, the differences in ADDPMS between the base run (Figure 2) and that displayed in Figure 9.)

Implications

General Implications

Normally, the objective of system dynamics simulation is policy analysis. A problem is defined in the generic manner: as a discrepancy between an observed state of affairs and a more desired one. Policy questions are considered which are perceived to be logically or historically relevant to the problem. Finally, boundary setting (i.e., the choice of the model variables) is guided by the nature of the problem and by the policy questions to be addressed. Model outcomes are directed toward evaluating courses of action and making policy recommendations in terms of assessed effects upon the "problem system."

In this case, the effort has taken primarily a research orientation. What the project has been seeking are understandings. In a sense, this has not given quite as sharp a focus to the modelling work. Thus, the implications seem to have a broader dimensionality. The issue at the conclusion of the study seems to have less relationship to what to do than with what to think about.

What defines the relevance of our continuing efforts to understand the context of organizational stability and change is the history of research and conceptualization about planned change. As suggested earlier in the paper, the dominant theme of research on innovation has been upon the characteristics of innovators and upon the barriers to and tasks of adoption and implementation. The historical perspectives have been on persons in the early days of study and upon management in more recent writings and investigations.

This paper represents thematic development along the lines of the paper I presented at the last annual meeting of AERA (Gaynor, 1979). Last year's paper was a theoretical work. It represented a distillation of many years of involvement in and reflection upon the dynamics of systematic innovation. The thrust of our work in the past year, the work which is reported in this paper, has been empirical. But not empirical in what I consider to be the worst sense of the term--rank number crunching.

Rather, it is part of what we plan as a continuing effort to engage "subjects" as colleagues in a joint search for richer understandings of the crosspressures which are the fabric of organizational stability and change. We have not pretended that the data are "hard." They never are, and all the sophisticated statistical manipulation in the world doesn't make the data any harder than they were in the first instance.

We have assumed, quite reasonably I think, that there is a great deal of useful knowledge which is neither quantified nor written. We have assumed that there is a rich store of important information which is hard won by experience in schools and other organizations. Through an iterative and interactive process of data collection, we have tapped the experience of those in one elementary school who lived the "mini-life cycle" of one innovation.

Findings and implications will be fuller as more case studies using this method of research are undertaken. However, there seem to be a few tentative conclusions to be drawn from the present work.

Specific Implications

What one typically seeks from the modelling process are specific policy implications. Several have emerged from this study, although their presentation is tempered by the knowledge that drawing conclusions from them for practice is not simple. On the other hand, they suggest ways of thinking about the context of innovation which seem to transcend simple management strategies.

A set of assumptions was derived from the interview data upon which the model was constructed. There was much evidence in these data that supported the importance of the

principal's role in determining the success or failure of an innovation. Clearly, for example, the principal is an important influential in the school. The principal also embodies authority and is the key agent through whom policy decisions are formalized. The principal is also a controller of resources without which, the data suggest, it can be difficult or impossible to proceed with a piece of curriculum.

It is also clear, though, that the principal is not an all-powerful figure. There are very strong forces operating in and around the school which seriously affect the ability, and desire, of the principal and the teachers to go on with an innovation. It is only when strategies are available to alter or neutralize constraining elements that significant long-term change becomes feasible.

For example, in this analysis, three elements were identified as critical in the failure of DMP to sustain itself in the Mercury School for more than a few years. These included the actual and perceived fit of the innovation with the developmental learning characteristics of the students and the relationship between the school's curriculum and that of the rest of the school district. Carriers of the school district norms and practices in the situation studied were the standardized tests and the effects of transfer students on the teachers who had to deal with them.

The interaction among these elements stands as a useful example of the importance of attending not only to the specific values of the variables over time but to the dynamics which produce those values. The discussion (supra, p. 32) asserted the position that something which is demonstrably "good" may turn out, in conjunction with other existing conditions, to have unanticipated "bad" effects. Who can deny that introducing a curriculum which has a high degree of fit with the students' developmental learning characteristics is "good"? On the other hand, it should be clear that the evident benefits of a particular innovation may not be sufficient to guarantee its success in the long run. What the analysis suggests is that to the extent that the innovation is inconsistent with important norms and practices in the school district, it may, by its very implementation create the pressures that ultimately lead to its discontinuation.

In assessing the implications of this analysis for practice, another difficulty arises. It is one thing, in working with the model, to define a test condition such as "withdrawing the effects of . . . ." This is a simple technical task to perform on the model. It is a challenging task, however, to translate the test condition into operational terms in a school. It seems important, then, to give attention to this problem in defining implications for practice.

Let us deal, by way of illustration, with the three

variables we have been discussing. What would it mean, in practice, to withdraw the effects of the the test scores and transfer rates? Does it make sense, for example, to think about a strategy in which one can successfully argue that students in a special program should not have to take the districtwide tests? Is it practical to assert that they should be permitted to take other tests which are more consistent with the objectives of that program? This is not to say that such a strategy could not be successfully implemented.

On the other hand, a simpler strategy may follow from the analysis. This is to engage students in a special preparation program for a period of time prior to taking the standardized tests. In this way, they may become familiar with the traditional vocabulary of those tests and with their modal formats. Thus, the special program may be protected from the deleterious impact of the districtwide testing program by a strategy of doing some "teaching to the test" (which, it can be argued, may be perfectly legitimate if what is being taught is not the content of the test, but rather its format.)

By the same token, while it may not be feasible to isolate the school from the effects of school district transfer policies, an important strategy to protect the environment of the special program may be to buffer the impact of these transfer students in other ways. For example, incoming transfer students might be required to undergo an intensive orientation program prior to placement in regular classes.

It is equally difficult to assess the practical implications of achieving a "high student fit" with the innovation. For one thing, it is no simple task, given the current state of the art, to identify a curriculum which has such a fit in reality. Another complication lies in the important distinction between actual and perceived fit. (The model makes this distinction.) Assuming that as may be true in some cases, that the real fit of the innovation to students' learning characteristics is better than some teachers perceive it to be, a so-called "normative-reeducative" strategy of organization development may be in order. It is well known from experience, however, that these strategies can be tenuous. They often fly in the face of beliefs acquired during professional training and even in the teachers' own schooling experiences. Many of these beliefs are reinforced by other teachers within the school, and altering these may, in practice, be no simple task.

It has not been the purpose of this discussion to make substantive policy recommendations. Rather, the intent has been to illustrate the problem and the process of moving from analytic results to practical policy formulations. What seems critical, however, is that the analytic process focuses the planner upon issues of relationship and interaction and upon problems as patterns of response.

From a systems perspective, wisdom is a sense of context. The implication is that wisdom lies in longer time frames and in attending more to multiple and reciprocal causes. Ecologists remind us that it is not possible to do only one thing at a time. Whatever policy one pursues in the name of short-term interests will have long-term systemic consequences. Our experience with pesticides and drugs has told us more about this concept than we may have wished to know. At the same time, in the service of singular goals, it is often necessary to adopt complex strategies. Our analysis of the implementation and discontinuation of DMP in the Mercury School certainly seems to support this admonition.

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APPENDIX

```
*                Mercury School Model
*             A.K. Gaynor -- February, 1980
*
*
*                Curriculum Sector
*
*
*             Primary Grades
*
*
*        Level of DMP in the Primary Grades
*
l pdmp.k=(pdmp.J+dt*(ripdmp.Jk-rdpdmp.Jk))
n pdmp=pdmpn
c pdmpn=100
*
*   pdmp=primary grade dmp (units)
*   dt=simulation time interval of computation (fraction/mo)
*   ripdmp=rate of increase in pdmp (units/mo)
*   rdpdmp=rate of decrease in pdmp (units/mo)
*   pdmpn=initial value of pdmp (units)
*
r ripdmp.kl=(((dipdmp.k*easidp.k)/cat)+eppidp.k)
a dipdmp.k=(ptddmp.k-pdmp.k)*sw1.k
a sw1.k=clip(1,0,ptddmp.k,pdmp.k)
a easidp.k=table(teasidp,prddmp.k*evote2.k,0,100,25)
t teasidp=0,.2,1,1.5,2
c cat=36
a eppidp.k=step(ppht.k,pptime)*evote2.k
a ppht.k=fepol*(100-pdmp.k)
c pptime=0
c fepol=.25
a evote2.k=clip(0,1,swv2.k,1)
a swv2.k=x.k*y.k
a x.k=clip(1,0,time.k,vtime2)
a y.k=clip(0,1,addpms.k,ravote)
c vtime2=60
c ravote=50
*
*   ripdmp=rate of increase in pdmp (units/mo)
*   dipdmp=desired increase in pdmp (units)
*   easidp=effect of administrative support on increases in dmp
*      (dimensionless)
*   cat=curriculum adjustment time (months)
*   eppidp=effect of primary grade policy on increases in pdmp (dimensionless)
*   evote2=effect of vote 2 (dimensionless)
*   ptddmp=primary grade teachers desired dmp (units)
*   pdmp=primary grade dmp (units)
*   sw1=switch 1 (dimensionless)
*   clip=a branching function
*   table(tabhl)=a list of 'y' coordinates corresponding to
*      the 'x' scale values indicated
*   teasidp=table of easidp values
```

```
*    prddmp=principal's desired dmp (units)
*    step=increase in a rate of a stated height at a stated time
*    ppht=primary policy step height (units/mo)
*    pptime=time of implementation of primary policy (months)
*    fepol=fractional effect of policy (dimensionless)
*    pdmp=primary grade dmp (units)
*    sw=switch (dimensionless)
*    tippti=table of ippti values
*    swv2=switch for vote 2 (dimensionless)
*    x=dummy variable
*    y=dummy variable
*    vtime2=time of vote 2 (months)
*    addpms=average desired dmp in the Mercury School (units)
*    revote=required level of desired dmp to retain the program (units)
*
r rdpdmp.kl=(ddpdmp.k/cat)+easddp.k+(pev2pd.k*sw11.k)
a ddpdmp.k=(pdmp.k-ptddmp.k)*sw2.k
a sw2.k=clip(0,1,ptddmp.k,pdmp.k)
a easddp.k=((pdmp.k-prddmp.k)/adt.k)*sw12.k
a adt.k=tabhl(tadt,prddmp.k*evote2.k,0,50,25)
t tadt=1,12,24
a sw12.k=clip(0,1,prddmp.k,pdmp.k)
a pev2pd.k=pdmp.k/polat
c polat=1
*
*    rdpdmp=rate of decrease in pdmp (units/mo)
*    ddpdmp=desired decrease in pdmp (units)
*    cat=curriculum adjustment time (months)
*    easddp=effect of administrative support on decreases in pdmp
*       (dimensionless)
*    pev2pd=policy effect of vote 2 on the rate of decrease in
*       primary dmp (units/mo)
*    sw11=switch 11 (dimensionless)
*    pdmp=primary grade dmp (units)
*    ptddmp=primary grade teachers desired dmp (units)
*    sw2=switch 2 (dimensionless)
*    clip=a branching function
*    prddmp=principal's desired dmp (units)
*    adt=administrative discontinuation time (months)
*    sw12=switch 12 (dimensionless)
*    table(tabhl)=a list of "y" coordinates corresponding to
*       the "x" scale values indicated
*    tadt=table of adt values
*    evote2=effect of vote 2 (dimensionless)
*    polat=policy adjustment time (months)
*
*
*         Primary Teachers Desired Level of DMP
*
l ptddmp.k=ptddmp.j+dt*(iptddp.jk-dptddp.jk)
n ptddmp=ptddpn
c ptddpn=90
*
*    ptddmp=primary grade teachers desired dmp (units)
*    dt=simulation time interval of computation (fraction/mo)
*    iptddp=rate of increase in primary teachers desired dmp (units/mo)
*    dptddp=rate of decrease in primary teachers desired dmp(units/mo)
*    ptddpn=initial value of ptddmp (units)
```

```
*
r iptddp.kl=nfiddp*(100-ptddmp.k)*eprpti.k*eitpti.k*eppti.k*epsfdi.k
x *etfdip.k*etspti.k*(1/pewddp.k)
c nfiddp=.005
a eprpti.k=delay3(iprpti.k,12)
n iprpti=1
a iprpti.k=tabhl(tiprpti,prddmp.k-ptddmp.k,-20,20,10)
t tiprpti=.5,.67,1,1.5,2
a eitpti.k=delay3(iitpti.k,12)
n iitpti=1
a iitpti.k=tabhl(tiitpti,itddmp.k-ptddmp.k,-20,20,10)
t tiitpti=.85,.95,1,1.1,1.15
a eppti.k=delay3(ippti.k,12)
n ippti=1
a ippti.k=tabhl(tippti,ppddmp.k-ptddmp.k,-20,20,10)
t tippti=.85,.95,1,1.05,1.15
a epsfdi.k=tabhl(tepsfdi,ppsfdp.k-ptddmp.k,-30,30,10)
t tepsfdi=.2,.4,.67,1,1.5,2.5,5
a etfdip.k=delay3(itfdip.k,6)
n itfdip=1
a itfdip.k=eptddn.k*pestr.k
a eptddn.k=tabhl(teptddn,sddmp.k-pdmp.k,-30,30,10)
t teptddn=.85,.95,.98,1,1.05,1.1,1.15
a sddmp.k=tabhl(tsddmp,time.k,0,60,12)
t tsddmp=0,0,0,0,0,0
a pestr.k=pestr1.k+pestr2.k
a pestr1.k=tabhl(tpestr1,str.k,0,30,10)*sw9.k
t tpestr1=1,1.05,1.08,1.15
a pestr2.k=tabhl(tpestr2,str.k,0,30,10)*sw10.k
t tpestr2=1,.98,.95,.85
a sw9.k=clip(1,0,sddmp.k-pdmp.k,0)
a sw10.k=clip(0,1,sddmp.k-pdmp.k,0)
a str.k=tabhl(tstr,time.k,0,60,12)
t tstr=2,2,50,30,30,12
a etspti.k=delay3(itspti.k,6)
n itspti=1
a itspti.k=tabhl(titspti,test.k,.5,1,.5)
t titspti=.9,1.1
a test.k=tabhl(ttest,dsdnp.k,-40,40,40)
t ttest=.5,1,.5
a dsdnp.k=admpms.k-sddmp.k
a admpms.k=(pdmp.k+2*idmp.k)/3
a pewddp.k=owldmp*peddpw.k*ess.k
c owldmp=1.5
a peddpw.k=tabhl(tpeddpw,ptddmp.k,0,100,25)
t tpeddpw=2,1.5,1,.75,.67
a ess.k=1
*
*   iptddp=rate of increase in primary teachers desired dmp (units/mo)
*   nfiddp=normal fractional rate of increase in itddmp (fraction/mo)
*   ptddmp=primary grade teachers desired dmp (units)
*   eprpti=effectof the principal on iptddp (dimensionless)
*   eitpti=effect of intermediate teachers on iptddp (dimensionless)
*   eppti=effect of parents on iptddp (dimensionless)
*   epsfdi=effect of perceived primary student fit with dmp on iptddp
*      (dimensionless)
*   etfdip=effect of perceived transfer student fit with dmp on iptddp
*   itfdip=indicated value of etfdip (dimensionless)
```

```
*    etspti=effect of standardized test scores on iptddp (dimensionless)
*    pewddp=effect of perceived dmp workload on iptddp (dimensionless)
*    delay3=third-order exponential delay of the length shown in (  )
*    iprpti=indicated value of eprpti (dimensionless)
*    tiprpti=table of iprpti values
*    table(tabh1)=a list of "y" coordinates corresponding to
*       the "x" scale values indicated
*    prddmp=principal's desired dmp (units)
*    iitpti=indicated value of eitpti (dimensionless)
*    tiitpti=table of iitpti values
*    itddmp=intermediate teachers desired dmp (units)
*    ippti=indicated value of eppti (dimensionless)
*    tippti=table of ippti values
*    ppddmp=primary parents desired dmp (units)
*    tepsfdi=table of epsfdi values
*    ppsfdp=perceived primary students fit with dmp (units)
*    eptddn=effect on primary transfer students of discrepancy with
*       school district norms & practices (dimensionless)
*    pestr=effect on primary grade teachers of the student transfer rate
*       (dimensionless)
*    teptddn=table of iptddn values
*    sddmp=school district level of dmp (units)
*    pdmp=primary grade dmp (units)
*    tsddmp=table of sddmp values
*    time=number of months in the model run (months)
*    pestr1=effect when sddmp>pdmp (dimensionless)
*    pestr2=effect when pdmp>sddmp (dimensionless)
*    tpestr1=table of pestr1 values
*    tpestr2=table of pestr2 values
*    str=student transfer rate (%/yr)
*    sw9=switch 9 (dimensionless)
*    sw10=switch 10 (dimensionless)
*    clip=a branching function
*    tstr=table of str values
*    itspti=indicated value of etspti (dimensionless)
*    test=test scores (fraction of expected test scores)
*    ttest=table of test values
*    dsdnp=discrepancy between school & district levels of dmp (units)
*    admpms=average dmp in Mercury School (units)
*    idmp=intermediate grade dmp (units)
*    owldmp=objective workload from dmp (dimensionless ratio)
*    peddpw=primary grade effect of desired dmp on perceived workload
*       (dimensionless)
*    ess=effect of special support on the effects of workload (dimensionless)
*    tpeddpw=table of peddpw values
*
r dptddp.kl=nfdddp*ptddmp.k*eprptd.k*eitptd.k*epptd.k*epsfdd.k
x *etfddp.k*etsptd.k*pewddp.k
c nfdddp=.005
a eprptd.k=1/eprpti.k
a eitptd.k=1/eitpti.k
a epptd.k=1/eppti.k
a epsfdd.k=1/epsfdi.k
a etfddp.k=1/etfdip.k
a etsptd.k=delay3(itsptd.k,6)
n itsptd=1
a itsptd.k=tabh1(titsptd,test.k,.5,1,.5)
t titsptd=1.1,.9
```

```
*
*   dptddp=rate of decrease in primary teachers desired dmp(units/mo)
*   nfdddp=normal fractional decrease in  desired dmp
*      (fraction/mo)
*   ptddmp=primary grade teachers desired dmp (units)
*   eprptd=effect of the principal on dptddp (dimensionless)
*   eitptd=effect of intermediate teachers on dptddp (dimensionless)
*   epptd=effect of parents on dptddp (dimensionless)
*   epsfdd=effect of perceived primary student fit with dmp on dptddp
*      (dimensionless)
*   etfddp=effect of transfer students on dptddp (dimensionless)
*   etsptd=effect of test scores on dptddp (dimensionless)
*   itsptd=indicated value of etsptd
*   pewddp=effect of perceived dmp workload on iptddp (dimensionless)
*   eprpti=effectof the principal on iptddp (dimensionless)
*   eitpti=effect of intermediate teachers on iptddp (dimensionless)
*   eppti=effect of parents on iptddp (dimensionless)
*   epsfdi=effect of perceived primary student fit with dmp on iptddp
*      (dimensionless)
*   etfdip=effect of perceived transfer student fit with dmp on iptddp
*      (dimensionless)
*   table(tabhl)=a list of "y" coordinates corresponding to
*      the "x" scale values indicated
*   tetsptd=table of etsptd values
*   test=test scores (fraction of expected test scores)
*
*
*            Intermediate Grades
*
*
*       Level of DMP in the Intermediate Grades
*
l idmp.k=idmp.j+dt*(riidmp.jk-rdidmp.jk)
n idmp=idmpn
c idmpn=0
*
*   idmp=intermediate grade dmp (units)
*   dt=simulation time interval of computation (fraction/mo)
*   riidmp=rate of increase in idmp (units/mo)
*   rdidmp=rate of decrease in idmp (units/mo)
*   idmpn=initial value of idmp (units)
*
r riidmp.kl=(((diidmp.k*easidi.k)/cat)+evote1.k)*vsw1.k
a diidmp.k=(itddmp.k-idmp.k)*sw3.k
a sw3.k=clip(1,0,itddmp.k,idmp.k)
a easidi.k=easidp.k
a evote1.k=step(iht.k,sttm.k)*vsw2.k
a iht.k=(90-(nriidp.k+idmp.k))*sw5.k
a sw5.k=clip(0,1,time.k,vtime1+6)
a nriidp.k=(diidmp.k*easidi.k)/cat
a sttm.k=vtime1
c vtime1=36
a vsw1.k=clip(1,0,time.k,vtime1)
a vsw2.k=clip(1,0,itddmp.k,nagree)*clip(1,0,time.k,vtime1-1)
c nagree=45
*
*   riidmp=rate of increase in idmp (units/mo)
*   diidmp=desired increase in idmp (units)
```

```
*   easidi=effect of administrative support on riidmp (dimensionless)
*   cat=curriculum adjustment time (months)
*   evote1=effects of vote 1(units/mo)
*   vsw1=vote switch 1 (dimensionless)
*   itddmp=intermediate teachers desired dmp (units)
*   idmp=intermediate grade dmp (units)
*   sw3=switch 3 (dimensionless)
*   clip=a branching function
*   easidp=effect of administrative support on increases in dmp
*      (dimensionless)
*   step=increase in a rate of a stated height at a stated time
*   iht=height of intermediate step (units/mo)
*   sttm=time of intermediate step (months)
*   vsw2=vote switch 2 (dimensionless)
*   ditddp=rate of decrease in itddmp (units/mo)
*   sw5=switch 5 (dimensionless)
*   time=number of months in the model run (months)
*   vtime1=time of vote 1 (months)
*   table(tabh1)=a list of "y" coordinates corresponding to
*      the "x" scale values indicated
*   nagree=needed level of intermediate teachers desired dmp to support
*      initial implementation in the intermediate grades (units)
*
r rdidmp.kl=(ddidmp.k/cat)+easddi.k+(pev2id.k*sw11.k)
a pev2id.k=idmp.k/polat
a sw11.k=clip(0,1,evote2.k,1)
a ddidmp.k=(idmp.k-itddmp.k)*sw4.k
a sw4.k=clip(0,1,itddmp.k,idmp.k)
a easddi.k=((idmp.k-prddmp.k)/adt.k)*sw13.k
a sw13.k=clip(0,1,prddmp.k,idmp.k)
*
*   rdidmp=rate of decrease in idmp (units/mo)
*   ddidmp=desired increase in idmp (units)
*   cat=curriculum adjustment time (months)
*   pev2id=policy effect of vote 2 on the rate of decrease in
*      intermediate dmp (units/mo)
*   idmp=intermediate grade dmp (units)
*   polat=policy adjustment time (months)
*   sw11=switch 11 (dimensionless)
*   clip=a branching function
*   evote2=effect of vote 2 (dimensionless)
*   itddmp=intermediate teachers desired dmp (units)
*   sw4=switch 4 (dimensionless)
*   easddi=effect of administrative support on rdidmp (dimensionless)
*   prddmp=principal's desired dmp (units)
*   adt=administrative discontinuation time (months)
*   sw13=switch 13 (dimensionless)
*
*
*        Intermediate Teachers Desired Level of DMP
*
l itddmp.k=itddmp.j+dt*(iitddp.jk-ditddp.jk)
n itddmp=itddpn
c itddpn=50
*
*   itddmp=intermediate teachers desired dmp (units)
*   dt=simulation time interval of computation (fraction/mo)
*   iitddp=rate of increase in itddmp (units/mo)
```

```
*   ditddp=rate of decrease in itddmp (units/mo)
*   itddpn=initial value of itddmp (units)
*
r iitddp.kl=nfiddp*(100-itddmp.k)*epriti.k*eptiti.k*epiti.k*eisfdi.k
x *etfdii.k*etsiti.k*(1/iewddp.k)
a epriti.k=delay3(ipriti.k,12)
n ipriti=1
a ipriti.k=tabhl(tipriti,prddmp.k-itddmp.k,-20,20,10)
t tipriti=.5,.67,1,1.5,2
a eptiti.k=delay3(iptiti.k,12)
n iptiti=1
a iptiti.k=tabhl(tiptiti,ptddmp.k-itddmp.k,-20,20,10)
t tiptiti=.5,.67,1,1.5,2
a epiti.k=delay3(ipiti.k,12)
n ipiti=1
a ipiti.k=tabhl(tipiti,ipddmp.k-itddmp.k,-20,20,10)
t tipiti=.75,.85,1,1.18,1.3
a eisfdi.k=tabhl(teisfdi,isfdmp.k-itddmp.k,-30,30,10)
t teisfdi=.2,.4,.67,1,1.5,2.5,5
a etfdii.k=delay3(itfdii.k,6)
n itfdii=1
a itfdii.k=eitddn.k*iestr.k*eietrs.k
a eietrs.k=clip(1,ileits.k,time.k,vtime1)
a ileits.k=1/(eitddn.k*iestr.k)
a eitddn.k=tabhl(teitddn,sddmp.k-idmp.k,-30,30,10)
t teitddn=.2,.4,.67,1,1.5,2.5,5
a iestr.k=iestr1.k+iestr2.k
a iestr1.k=tabhl(tiestr1,str.k,0,30,10)*sw7.k
t tiestr1=1,1.5,2.5,5
a iestr2.k=tabhl(tiestr2,str.k,0,30,10)*sw8.k
t tiestr2=1,.67,.4,.2
a sw7.k=clip(1,0,sddmp.k-idmp.k,0)
a sw8.k=clip(0,1,sddmp.k-idmp.k,0)
a etsiti.k=delay3(itsiti.k,6)
n itsiti=1
a itsiti.k=tabhl(titsiti,test.k,.5,1,.5)*eiewti.k
t titsiti=.1,1.1
a eiewti.k=clip(1,iiewti.k,time.k,vtime1)
a iiewti.k=tabhl(tiiewti,test.k,.5,1,.5)
t tiiewti=10,.9
a iewddp.k=owldmp*ieddpw.k*ess.k*eiewld.k
a ieddpw.k=tabhl(tiewddp,itddmp.k,0,100,25)
t tiewddp=2,1.5,1,.75,.67
a eiewld.k=clip(1,z.k,time.k,vtime1)
a z.k=1/(owldmp*ieddpw.k*ess.k)
*
*   iitddp=rate of increase in itddmp (units/mo)
*   nfiddp=normal fractional rate of increase in itddmp (fraction/mo)
*   epriti=effect of the principal on iitddp (dimensionless)
*   eptiti=effect of primary teachers on iitddp (dimensionless)
*   epiti=effect of parents on iitddp (dimensionless)
*   eisfdi=effect of perceived student fit with dmp on iitddp (dimensionless)
*   etfdii=effect of transfer students fit with dmp on iitddp (dimensionless)
*   itfdii=indicated value of etfdii
*   etsiti=effect of test scores on iitddp (dimensionless)
*   iewddp=effect of perceived workload on iitddp (dimensionless)
*   delay3=third-order exponential delay of the length shown in (  )
*   ipriti=indicated value of epriti (dimensionless)
```

```
*    table(tabh1)=a list of 'y' coordinates corresponding to
*       the 'x' scale values indicated
*    tipriti=table of iptiti values
*    prddmp=principal's desired dmp (units)
*    itddmp=intermediate teachers desired dmp (units)
*    iptiti=indicated value of eptiti (dimensionless)
*    tiptiti=table of iptiti values
*    ptddmp=primary grade teachers desired dmp (units)
*    ipiti=indicated value of epiti (dimensionless)
*    tipiti=table of ipiti values
*    ipddmp=intermediate parents desired dmp (units)
*    teisfdi=table of eisfdi values
*    isfdmp=intermediate students fit with dmp (units)
*    eitddn=effect on intermediate transfer students of discrepancy
*       (dimensionless)
*    iestr=effect on intermediate teachers of the transfer rate
*       (dimensionless)
*    eietrs=effect of intermediate experience with transfer students
*          (dimensionless)
*    clip=a branching function
*    ileits=indicated value of eietrs (dimensionless)
*    time=number of months in the model run (months)
*    vtime1=time of vote 1 (months)
*    teitddn=table of eitddn values
*    sddmp=school district level of dmp (units)
*    idmp=intermediate grade dmp (units)
*    iestr1=effect when sddmp>idmp (dimensionless)
*    iestr2=effect when idmp>sddmp (dimensionless)
*    tiestr1=table of iestr1 values
*    str=student transfer rate (%/yr)
*    tiestr2=table of iestr2 values
*    sw7=switch 7 (dimensionless)
*    sw8=switch 8 (dimensionless)
*    itsiti=indicated value of etsiti (dimensionless)
*    titsiti=table of itsiti values
*    test=test scores (fraction of expected test scores)
*    eiewti=effect of intermediate experience with dmp on itsiti (dimensionless)
*    iiewti=indicated value of eiewti (dimensionless)
*    time=number of months in the model run (months)
*    tileiti=table of ileiti values
*    ditddp=rate of decrease in itddmp (units/mo)
*    ieddpw=effect of itddmp on perceived dmp workload (dimensionless)
*    ess=effect of special support on the effects of workload (dimensionless)
*    eiewld=effect of intermediate experience with dmp workload (dimensionless)
*    tiewddp=table of iewddp values
*    z=dummy variable
*
r ditddp.kl=nfdddp*itddmp.k*epritd.k*eptitd.k*epitd.k*eisfdd.k
x *etfddi.k*etsitd.k*iewddp.k
a epritd.k=1/epriti.k
a eptitd.k=1/eptiti.k
a epitd.k=1/epiti.k
a eisfdd.k=1/eisfdi.k
a etfddi.k=1/etfdii.k
a etsitd.k=delay3(itsitd.k,6)
n itsitd=1
a itsitd.k=tabh1(titsitd,test.k,.8,1,.2)*eiewtd.k
t titsitd=5,.9
```

```
a eiewtd.k=clip(1,iiewtd.k,time.k,vtime1)
a iiewtd.k=tabhl(tiiewtd,test.k,.8,1,.2)
t tiiewtd=.2,1.1
*
*   ditddp=rate of decrease in itddmp (units/mo)
*   nfdddp=normal fractional decrease in  desired dmp
*   itddmp=intermediate teachers desired dmp (units)
*   epritd=effect of the principal on itddmp (dimensionless)
*   eptitd=effect of primary teachers on itddmp (dimensionless)
*   eisfdd=effect of intermediate student fit on itddmp (dimensionless)
*   etfddi=effect of transfer students fit with dmp on itddmp (dimensionless)
*   etsitd=effect of standardized test scores on itddmp (dimensionless)
*   iewddp=effect of perceived dmp workload on itddmp (dimensionless)
*   epriti=effect of the principal on iitddp (dimensionless)
*   eptiti=effect of primary teachers on iitddp (dimensionless)
*   epiti=effect of parents on iitddp (dimensionless)
*   eisfdi=effect of perceived student fit with dmp on iitddp (dimensionless)
*   etfdii=effect of transfer students fit with dmp on iitddp (dimensionless)
*   delay3=third-order exponential delay of the length shown in (  )
*   itsitd=indicated value of etsitd (dimensionless)
*   table(tabhl)=a list of 'y' coordinates corresponding to
*      the 'x' scale values indicated
*   titsitd=table of itsitd values
*   test=test scores (fraction of expected dmp on itsiti)
*   eiewtd=effect of intermediate experience with dmp on itsitd (dimensionless)
*   clip=a branching function
*   iiewtd=indicated value of eiewtd (dimensionless)
*   time=number of months in the model run (months)
*   vtime1=time of vote 1 (months)
*   tiiewtd=table of iiewtd values
*
*                    Student Sector
*
*
*               Primary Students
*
l psfdmp.k=psfdmp.j+dt*cpfft.jk
n psfdmp=psfdpn
c psfdpn=100
*
*   psfdmp=primary students fit with dmp (units)
*   dt=simulation time interval of computation (fraction/mo)
*   cpfft=change in primary student fit with dmp from teaching
*      (units/mo)
*      changes in student population (units/mo)
*   psfdpn=initial value of psfdmp (units)
*
r cpfft.kl=((pdmp.k-psfdmp.k)/sfat)*psfasw.k
a psfasw.k=clip(1,0,pdmp.k,psfdmp.k)
c sfat=24
*
*   cpfft=change in primary student fit with dmp from teaching
*        (units/mo)
*   pdmp=primary grade dmp (units)
*   psfdmp=primary students fit with dmp (units)
*   sfat=student fit adjustment time (months)
*   psfasw=primary student fit adjustment switch (dimensionless)
*
```

```
l ppsfdp.k=ppsfdp.j+dt*cppsf.jk
n ppsfdp=ppsfdn
c ppsfdn=100
*
*   ppsfdp=perceived primary student fit with dmp (units)
*   dt=simulation time interval of computation (fraction/mo)
*   cppsf=rate of change in perceived primary student fit (units/mo)
*   ppsfdn=initial value of ppsfdp (units)
r cppsf.kl=((psfdmp.k-ppsfdp.k)/percat)*eoldf.k
c percat=600
a eoldf.k=table(teoldf.k,oldf.k,0,10,10)
t teoldf=1,25
a oldf.k=table(toldf.k,time.k,0,72,12)
t toldf=0,0,0,0,0,0,0
*
*   cppsf=rate of change in perceived primary student fit (units/mo)
*   psfdmp=primary student fit with dmp (units)
*   ppsfdp=perceived primary student fit with dmp (units)
*   percat=perception adjustment time (months)
*   eoldf=effect of opportunities to learn about developmental fit
*        (dimensionless)
*   table (tabhl)=a list of "y" coordinates corresponding to
*        the "x" scale of values indicated
*   teoldf=table of eoldf values
*   oldf=opportunities to learn about developmental fit (units)
*   toldf=table of oldf values
*
*
*             Intermediate Students
*
l isfdmp.k=isfdmp.j+dt*cifft.jk
n isfdmp=isfdpn
c isfdpn=40
*
*   isfdmp=intermediate students fit with dmp (units)
*   dt=simulation time interval of computation (fraction/mo)
*   cifft=change in intermediate student fit with dmp from teaching
*      (units/mo)
*   isfdpn=initial value of isfdmp (units)
*
r cifft.kl=((idmp.k-isfdmp.k)/sfat)*isfasw.k
a isfasw.k=clip(1,0,idmp.k,isfdmp.k)
*
*
*   cifft=change in intermediate student fit with dmp from teaching
*        (units/mo)
*   idmp=intermediate grade dmp (units)
*   isfdmp=intermediate students fit with dmp (units)
*   sfat=student fit adjustment time (months)
*   isfasw=intermediate student fit adjustment time (months)
*   clip=a branching function
*
l pisfdp.k=pisfdp.j+dt*cpisf.jk
n pisfdp=pisfdn
c pisfdn=40
*
*   pisfdp=perceived intermediate student fit with dmp (units)
*   dt=simulation time interval of computation (fraction/mo)
```

```
*   cpisf=rate of change in pisfdp (units/mo)
*   pisfdn=initial value of pisfdp (units)
*
r cpisf.kl=((isfdmp.k-pisfdp.k)/percat)*eoldf.k
*
*   cpisf=rate of change in pssfdp (units/mo)
*   isfdmp=intermediate student fit with dmp (units)
*   pisfdp=perceived intermediate student fit with dmp (units)
*   percat=perception adjustment time (months)
*   eoldf=effect of opportunites to learn about developmental fit
*        (dimensionless)
*
*
*                    Principal Sector
*
*
l prddmp.k=prddmp.J+dt*ncprd.Jk
n prddmp=prddpn
c prddpn=100
*
*   prddmp=principal's desired dmp (units)
*   dt=simulation time interval of computation (fraction/mo)
*   ncprd=principal's desired dmp (units)
*   prddpn=initial value of prddmp (units)
*
r ncprd.kl=(addpms.k-prddmp.k)/prat
a addpms.k=(ptddmp.k+2*itddmp.k)/3
c prat=60
*
*   ncprd=principal's desired dmp (units)
*   addpms=average desired dmp in the Mercury School (units)
*   prddmp=principal's desired dmp (units)
*   prat=principal's adjustment time (months)
*   ptddmp=primary grade teachers desired dmp (units)
*   itddmp=intermediate teachers desired dmp (units)
*
*
*                    Parent Sector
*
*
*              Primary Grade Parents Desired DMP
*
l ppddmp.k=ppddmp.J+dt*ncppd.Jk
n ppddmp=ppddpn
c ppddpn=50
*
*   ppddmp=primary parents desired dmp (units)
*   dt=simulation time interval of computation (fraction/mo)
*   ncppd=net change in ppddmp (units/mo)
*   ppddpn=initial value of ppddmp (units)
*
r ncppd.kl=(ptddmp.k-ppddmp.k)/pat
c pat=120
*
*   ncppd=net change in ppddmp (units/mo)
*   ptddmp=primary grade teachers desired dmp (units)
*   ppddmp=primary parents desired dmp (units)
*   pat=parent adjustment time (months)
```

```
*
*
*        Intermediate Grade Parents Desired DMP
*
l ipddmp.k=ipddmp.J+dt*ncipd.Jk
n ipddmp=ipddpn
c ipddpn=40
*
*   ipddmp=intermediate parents desired dmp (units)
*   dt=simulation time interval of computation (fraction/mo)
*   ncppd=net change in ppddmp (units/mo)
*   ipddpn=initial value of ipddmp (units)
*
r ncipd.kl=(itddmp.k-ipddmp.k)/pat
*
*   ncppd=net change in ppddmp (units/mo)
*   itdomp=intermediate teachers desired dmp (units)
*   ipddmp=intermediate parents desired dmp (units)
*   pat=parent adjustment time (months)
*
*
*     Simulation Control Statements
*
print ptddmp,itddmp,addpms
plot admpms=a,idmp=i,pdmp=p(0,100)
spec dt=.25,prtper=4,pltper=4
n time=ntime
c ntime=0
c length=72
```